USAARL Report 76-20

LENS MATERIAL EVALUATION

(GOGGLES, SUN, WIND, AND DUST)

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May 1976

Final Report

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 76-20	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LENS MATERIAL EVALUATION (GOGGLES, SUN, WIND, AND DUST)		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Isaac Behar, Ph.D. MAJ Roger W. Wiley, Ph.D.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Bio-Optics Division (SGRD-UAO) US Army Aeromedical Research Laboratory Fort Rucker, AL 36362		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA 1498
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Aeromedical Research Laboratory SGRD-UAC Fort Rucker, AL 36362		12. REPORT DATE May 1976 13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) US Army Medical R & D Command Washington, DC		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Goggles (Sun, Wind, and Dust)
Optical Evaluation
Polycarbonate Lenses
Protective Goggles
Abrasion Test
Optical Distortion Test

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Optical evaluations of lenses considered as candidates to replace the visor in the combat vehicle crewman's protective goggles are described. The four areas of optical evaluation were: spectral transmission, haze, optical distortion, and abrasion resistance. All of the lenses were found to have adequate properties of transmissivity and freedom from haze. However, none of the lenses submitted for evaluation were medically acceptable because of excessive optical distortion. The optical coatings under consideration to increase

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scratch resistance of the polycarbonate lenses provided only negligible improvement. If polycarbonate is determined to be the material of choice, a higher optical quality should be used and a better method of providing abrasion resistance should be sought.

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SUMMARY

Optical evaluations of lenses considered as candidates to replace the visor in the combat vehicle crewman's protective goggles are described. The four areas of optical evaluation were: spectral transmission, haze, optical distortion, and abrasion resistance. All of the lenses were found to have adequate properties of transmissivity and freedom from haze. However, none of the lenses submitted for evaluation were medically acceptable because of excessive optical distortion. The optical coatings under consideration to increase scratch resistance of the polycarbonate lenses provided only negligible improvement. If polycarbonate is determined to be the material of choice, a higher optical quality should be used and a better method of providing abrasion resistance should be sought.

Robert W. Bailey

ROBERT W. BAILEY
COL, MSC
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INTRODUCTION

The combat vehicle crewman's goggle (goggle, sun, wind, and dust, NSN 8465-00-161-4068) is presently being modified to provide improved ballistic protection. The modification program consists of two phases. The first phase involves developing an immediate replacement for the visor which will fit into the present lens carrier. The second phase is a longer range attempt to improve the visor and carrier design.

The U S Army Natick Research and Development Command has been given overall responsibility to manage both phases of the product improvement. In support of the "quick fix" effort, NARADCOM requested the U S Army Aeromedical Research Laboratory to provide an optical evaluation of candidate replacement lenses for the goggles[1]. This report presents the results of that optical evaluation.

METHODS AND RESULTS

NARADCOM provided the lens materials to be evaluated. The lenses supplied were extruded polycarbonate of two thicknesses (.030 inch and .040 inch). The samples included untreated lenses and lenses which had been coated with one of four possible coatings developed to provide increased resistance to surface scratching. All of the optical tests were also completed on a cellulose acetate butyrate (CAB) lens which is currently used in the goggles.

The lenses were evaluated on four criteria: luminous transmissivity, distortion, haze, and scratch resistance. The methods of testing and results are given in subparagraphs a - d below.

a. Luminous transmissivity was measured with a Macbeth Quanta Log Densitometer. All polycarbonate samples had transmissivity values of 92-93%, while that of the acetate was 90%.

b. Haze was measured with a Gardner Hazemeter Model UX10 and Gardner Automatic Photometric Unit, "Colorgrad" model. Maximum aperture size was used. The following table gives the means of at least two samples.

MATERIAL	% HAZE
CAB	1.15
Poly Uncoated 30	0.95*, 1.36**
Poly Uncoated 40	0.57
Poly #650 30	0.62
Poly #650 40	0.36
Poly C-254 30	0.45
Poly C-254 40	0.56
Poly MXL 30	0.40
Poly MXL 40	0.33
Poly Abcite 30	0.96
Poly Abcite 40	0.63

*Visible adhesive residue remained after removing cover paper.
**Adhesive residue removed with Kodak Film Cleaner and soft lens tissue. Surface visibly scratched with "microscratches."

c. Distortion was evaluated according to the method described in MIL-V-43511(GL) for polycarbonate visors. Evaluation is made with an Ann Arbor Optical Company Optical Tester by comparing against visor distortion standards in the referenced Mil Spec. Distortion levels 1 through 5 are acceptable; 6 through 9 are unacceptable. Observations were made in the central, critical viewing area only and are given in the following table.

MATERIAL	DISTORTION RATING Sample 1 L	Sample 1 R	Sample 2 L	Sample 2 R	Sample 3 L	Sample 3 R
CAB	2	2	3	2	2	2
Poly, Uncoated 30	6	6	6	8		
Poly, Uncoated 40	7	9	8	9		
Poly #650 30	9	7	8	5		
Poly #650 40	9	8	9	8		
Poly C-254 30	9	9	7	8		
Poly C-254 40	8	7	7	6		
Poly MXL 30	9	7	6	7		
Poly MXL 40	9	9	8	9		
Poly Abcite 30	7	7	7	7		
Poly Abcite 40	8	9	9	9		

Samples of the distortions observed are shown in the Appendix. Because of physical constraints while taking the photographs, most of the pictures do not depict the distortion as great as that observed during the testing.

d. Abrasion resistance was measured by rubbing the surface with an "Optical Coating Tester Abrasion" D7630606 which permits the application of a controlled, uniform pressure of an abrader. During application, a 30-40 psi air jet was played on the surface to blow away particles. Criterion of abrasion resistance was the haze measurement (as obtained above with the modification of reduced aperture) after 5, 25, and 75 rubs. The observed haze percentages are given in the following table.

MATERIAL	PERCENT HAZE NUMBER OF RUBS		
	5	25	75
CAB	11.86	36.78	36.82
Poly, Uncoated 30	37.15	52.24	71.61
Poly, Uncoated 40	27.64	76.83	80.00
Poly #650 30	34.07	52.63	56.60
Poly #650 40	45.67	38.40	67.14
Poly C-254 30	33.99	42.56	79.99
Poly C-254 40	22.34	44.28	69.32
Poly MXL 30	33.00	40.00	66.42
Poly MXL 40	33.22	41.52	58.18
Poly Abcite 30	30.48	34.31	63.97
Poly Abcite 40	31.07	45.17	60.29

DISCUSSION

The relatively poorer transmission and haze values of the CAB can probably be attributed, at least in part, to the effects of aging, since the samples which we tested were slightly discolored (especially near the edges). The coatings applied to the polycarbonate did not measurably influence either of these optical characteristics. The extreme surface softness of uncoated polycarbonate was made evident when damage resulted from cleaning with Kodak Film cleaner and lens tissue.

All polycarbonate samples, whether uncoated or coated with any of the four coatings, had unacceptable levels of distortion. The CAB did not distort per se but reduced the contrast of the test pattern with what might be microscopic crazing. No distortion was observed with a polycarbonate hard coated aviator visor, indicating that the observed unacceptable distortion is not inherent to the material but reflects the method of manufacture.

The abrasion test results speak for themselves. After five rubs, the haze value for the acetate is only one-third that of the set of polycarbonate based materials. None of the hard coatings provided

consistent improvement according to this test. After 75 rubs, the acetate was no worse than the polycarbonate materials were after five rubs.

The present evaluation did not generate ballistic data on the lenses. However, a final selection of a replacement lens should most certainly include ballistic considerations since the primary purpose of changing from the present lens design is for the provision of improved ballistic protection. As noted previously, the lenses furnished by NARADCOM were of .030 inch and .040 inch thicknesses. USAARL has previously recommended[2] that the minimum thickness of the new lens should be .079 inch (2 mm). This recommendation was based upon a knowledge of the considerable ballistic information available in optical and government publications* and an appreciation of the recommendations of the American National Standards Institute. In an attempt to provide some increased eye protection, all ophthalmic lenses in all materials, have 2 mm minimum center thickness as required by ANSI Z80.1, 1972, para 2.4. Since the Army is represented on the ANSI Z80 Committee and abides by its regulations, the new lenses should have a 2 mm minimum thickness. These regulations were established only after considerable testing and discussions by leading optical, visual, and medical scientists.

*Information most relevant to the present development effort can be found in a publication by Robert J. Hassett, et al, "Protective Eye Shield Against Small Fragments," U.S. Naval Ordnance Laboratory Technical Report 70-202, 1 June 1970.

CONCLUSIONS

1. The light transmission and freedom from surface hazing were adequate in all of the lens samples provided.

2. The abrasion resistance of polycarbonate is very poor and the coatings used to increase resistance to abrasion provide negligible improvement. The cellulose acetate lens presently used in the goggles is far superior in resistance to surface abrasion.

3. All of the polycarbonate lenses (coated and untreated, both thicknesses) have unacceptable levels of distortion. This is attributed to the method of manufacture rather than a property inherent to the material itself since a polycarbonate helmet visor (injection molded) had no observable distortion.

RECOMMENDATIONS

1. Based upon these results, USAARL recommends no further consideration be given to lenses made in the grade of polycarbonate as that provided. The distortion levels observed are medically unacceptable.

2. The greater ballistic protection offered by polycarbonate is recognized. However, further effort should be made to find an acceptable technique of improving resistance to abrasion. The sample coatings provide negligible improvement.

3. USAARL maintains our original contention that a minimum lens thickness of 2 mm (.079 inch) is necessary to meet the standards established by American National Standards Institute and published in ANSI Z 80.1, 1972, para 2.4.

ACKNOWLEDGMENT

We wish to thank Dr. Wun C. Chiou, SP5 Chun K. Park and PFC Hal Chaikin for their technical assistance in conducting the testing.

REFERENCES

1. Natick ltr, DRXNM-VMP, dtd 3 May 76, subject: Goggles, Sun, Wind and Dust.

2. USAARL ltr, SGRD-UAC, dtd 20 Apr 76, subject: Eye Protection for Combat Vehicle Crewmen.

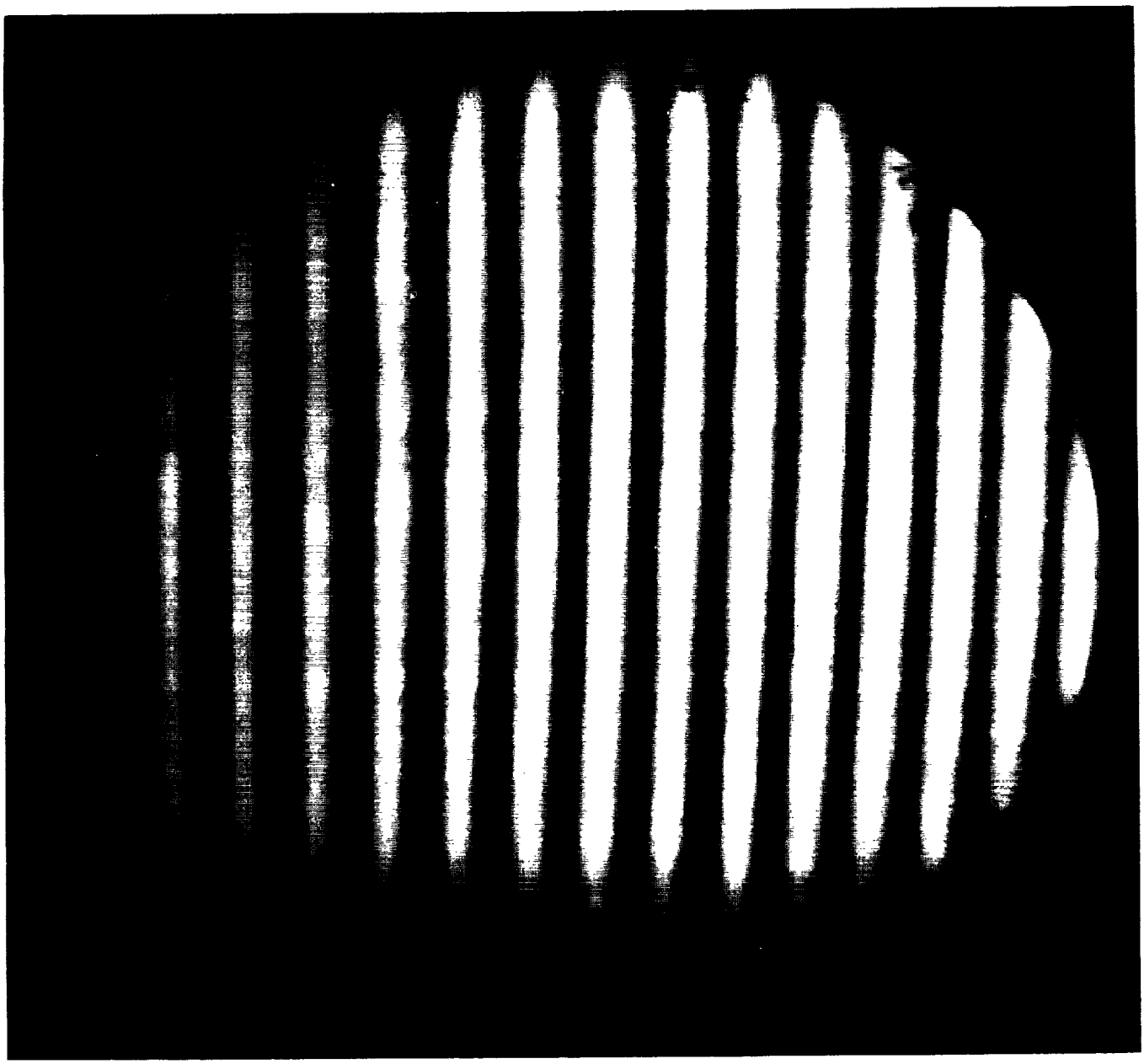

FIGURE 1. Control condition, i.e., no interposed lens. Minor optical blemishes reflect imperfections in the front surface mirror used in the apparatus.

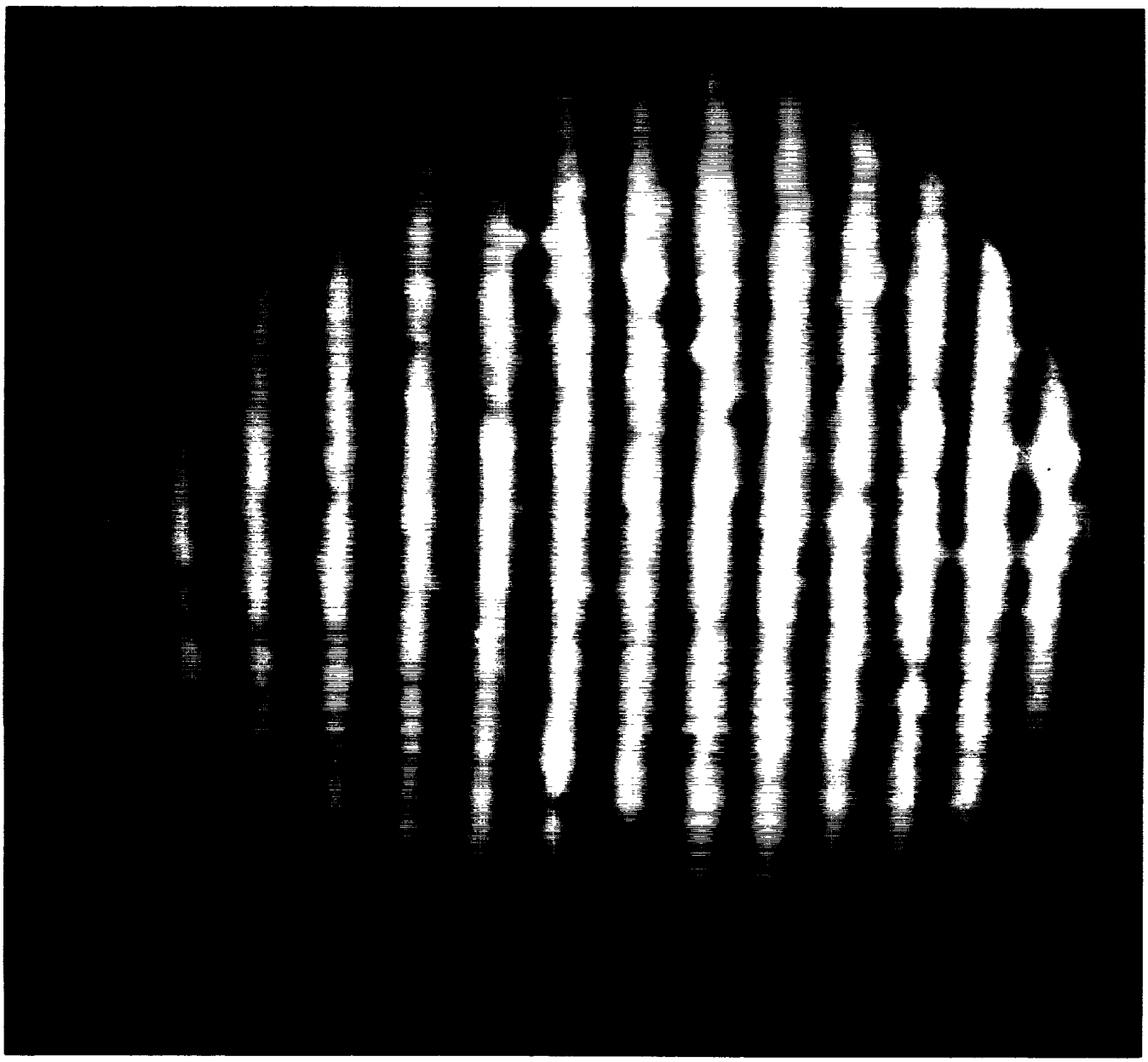

FIGURE 2. Cellulose acetate butyrate. Distortion is minimal although the figure discloses numerous localized imperfections.

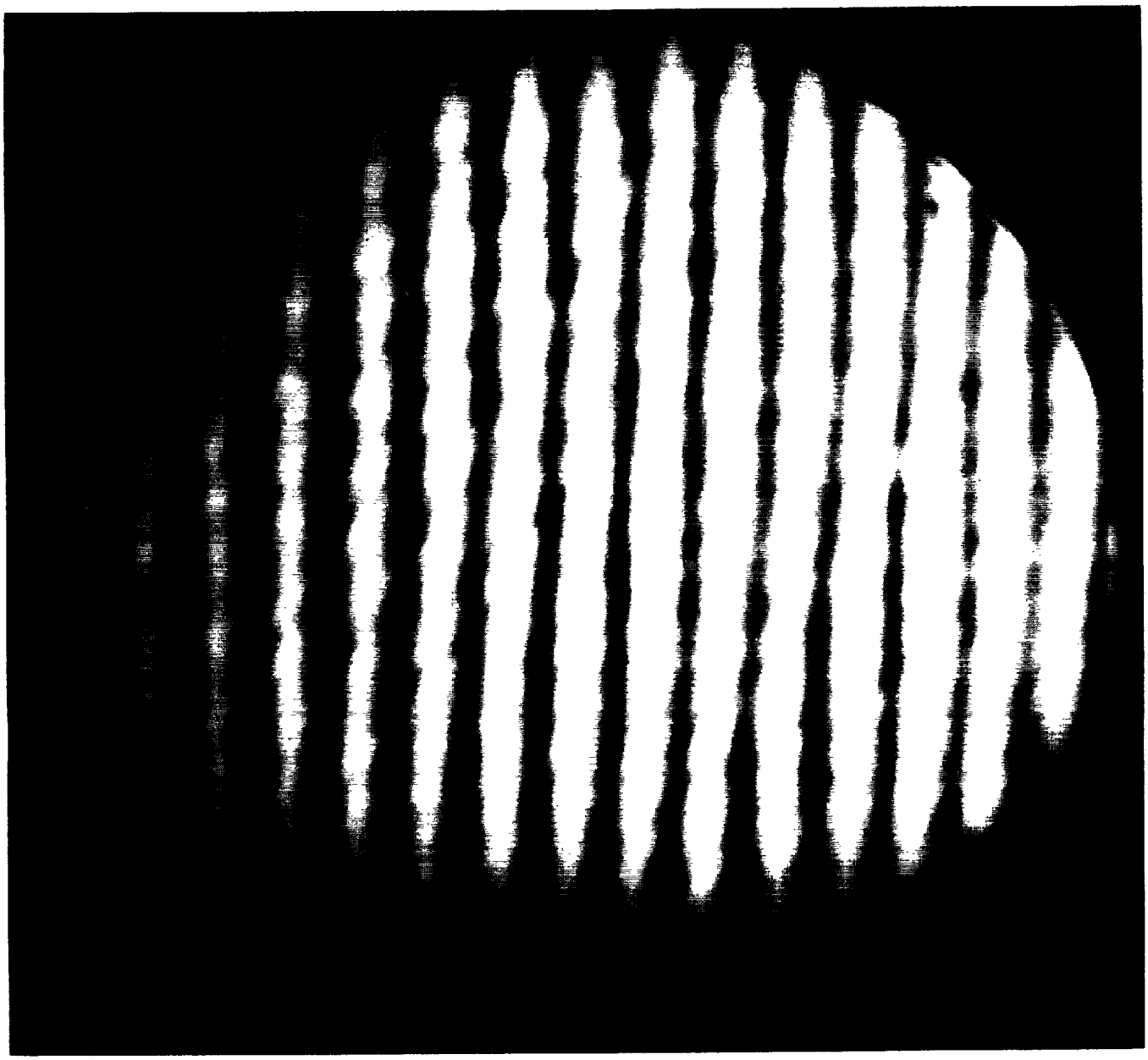

FIGURE 3. Polycarbonate, uncoated, 0.030". Numerous small striae are evident.

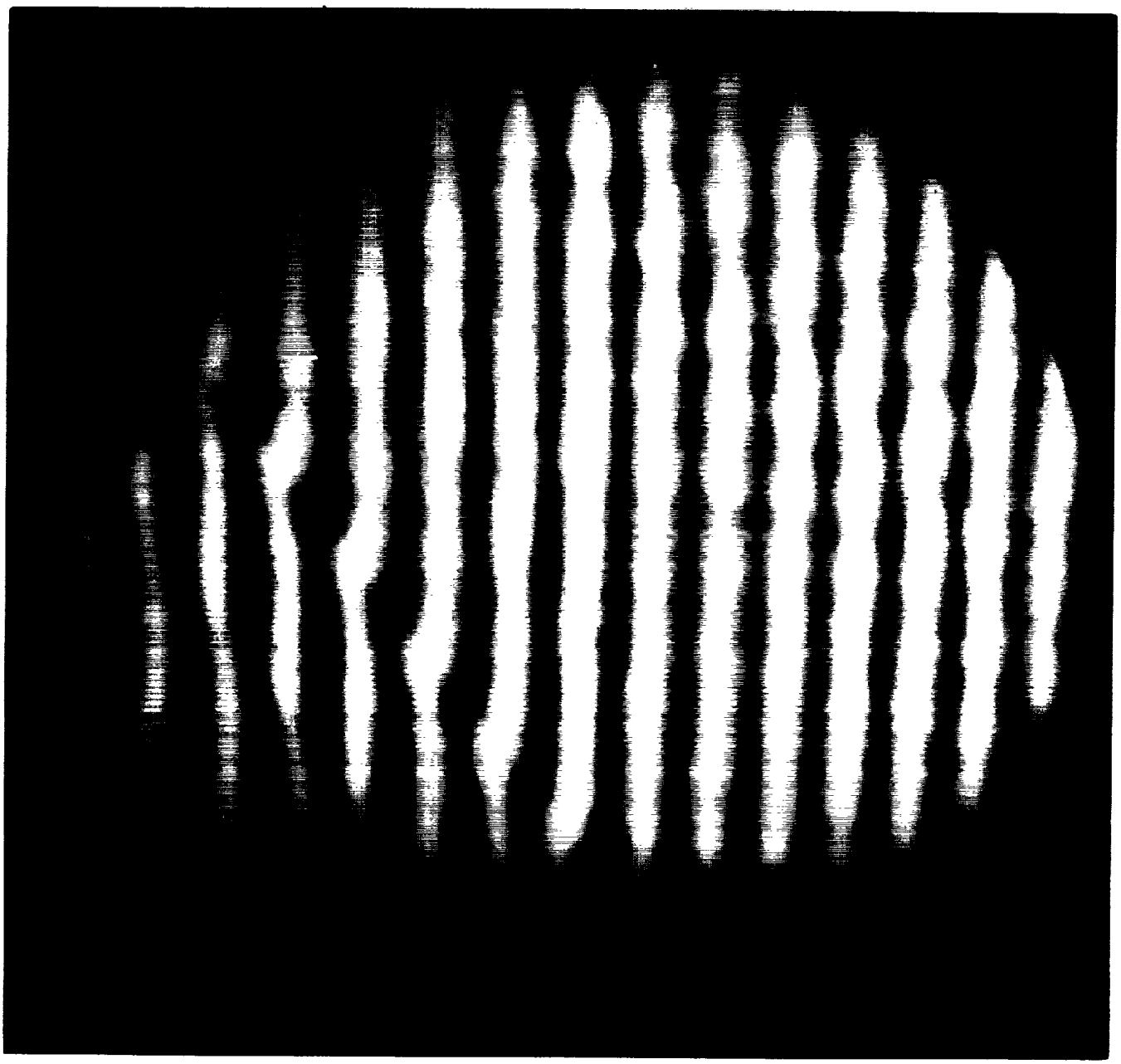

FIGURE 4. Polycarbonate, uncoated, 0.040". An imposingly large stria evident on left plus small striae on right.

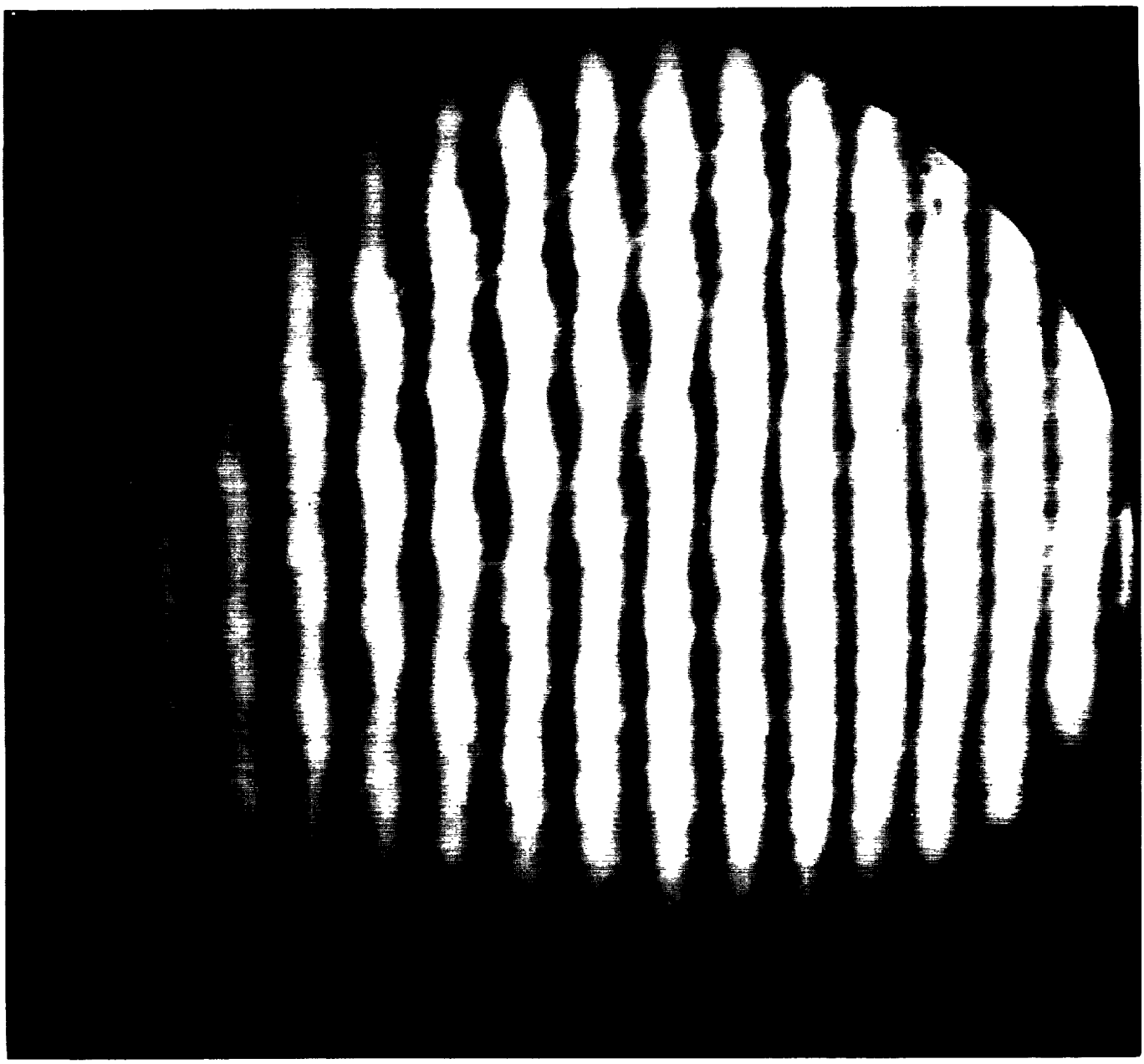

FIGURE 5. Polycarbonate, coating #650, 0.030". Ripple-like distortion is evident.

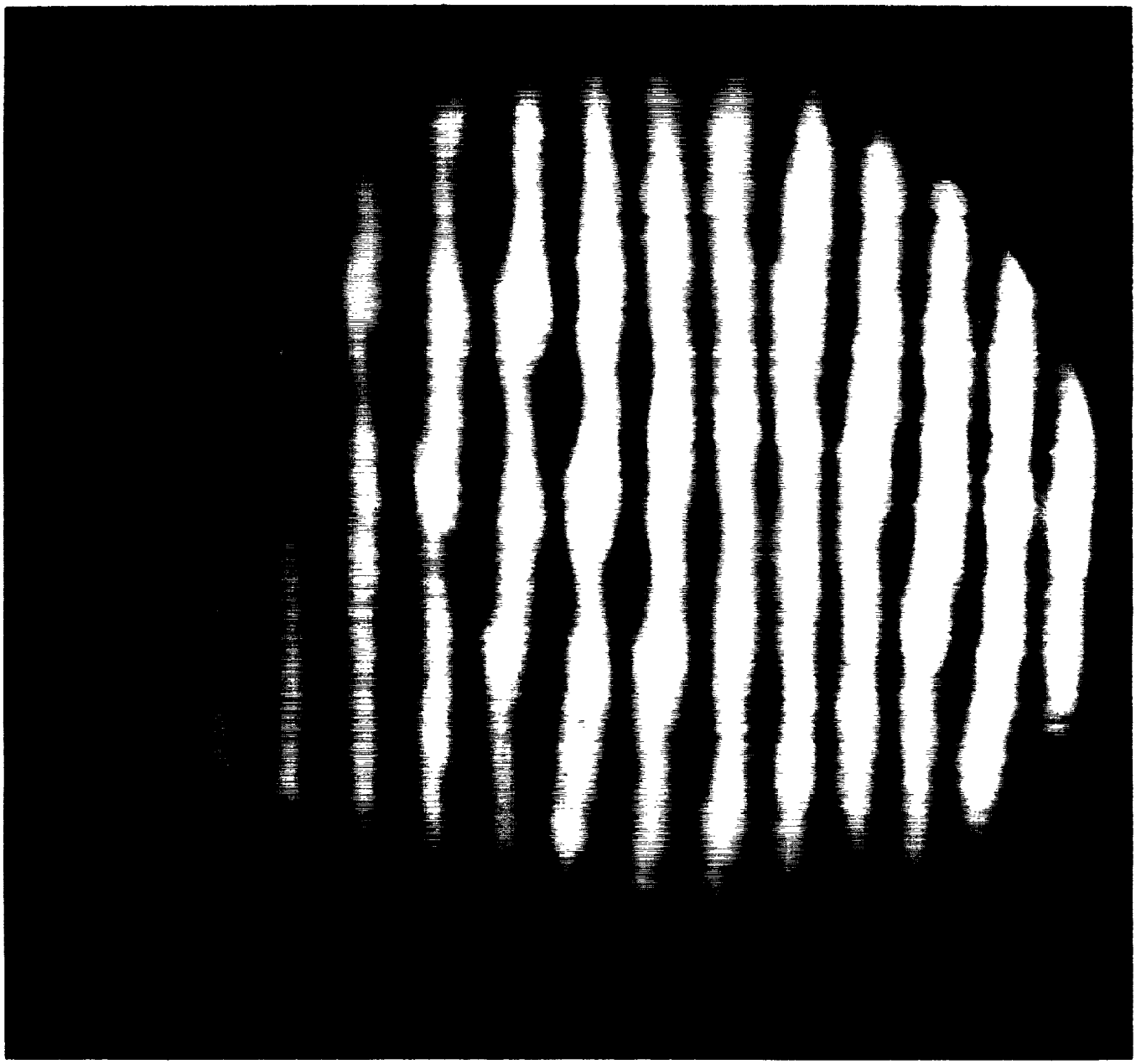

FIGURE 6. Polycarbonate, coating #650, 0.040". Small and large striae are evident.

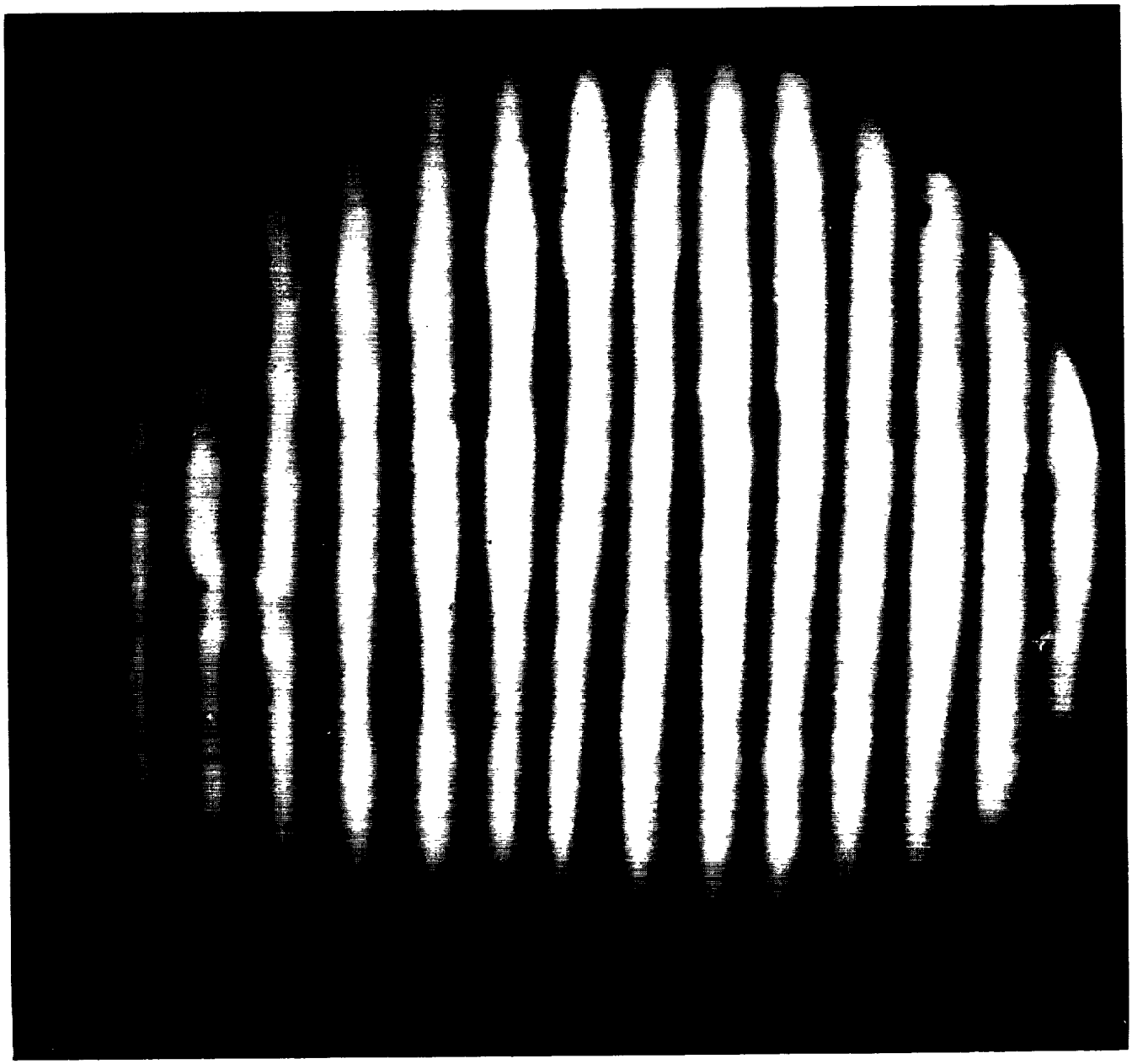

FIGURE 7. Polycarbonate, coating C-254, 0.030". Note large stria on left.

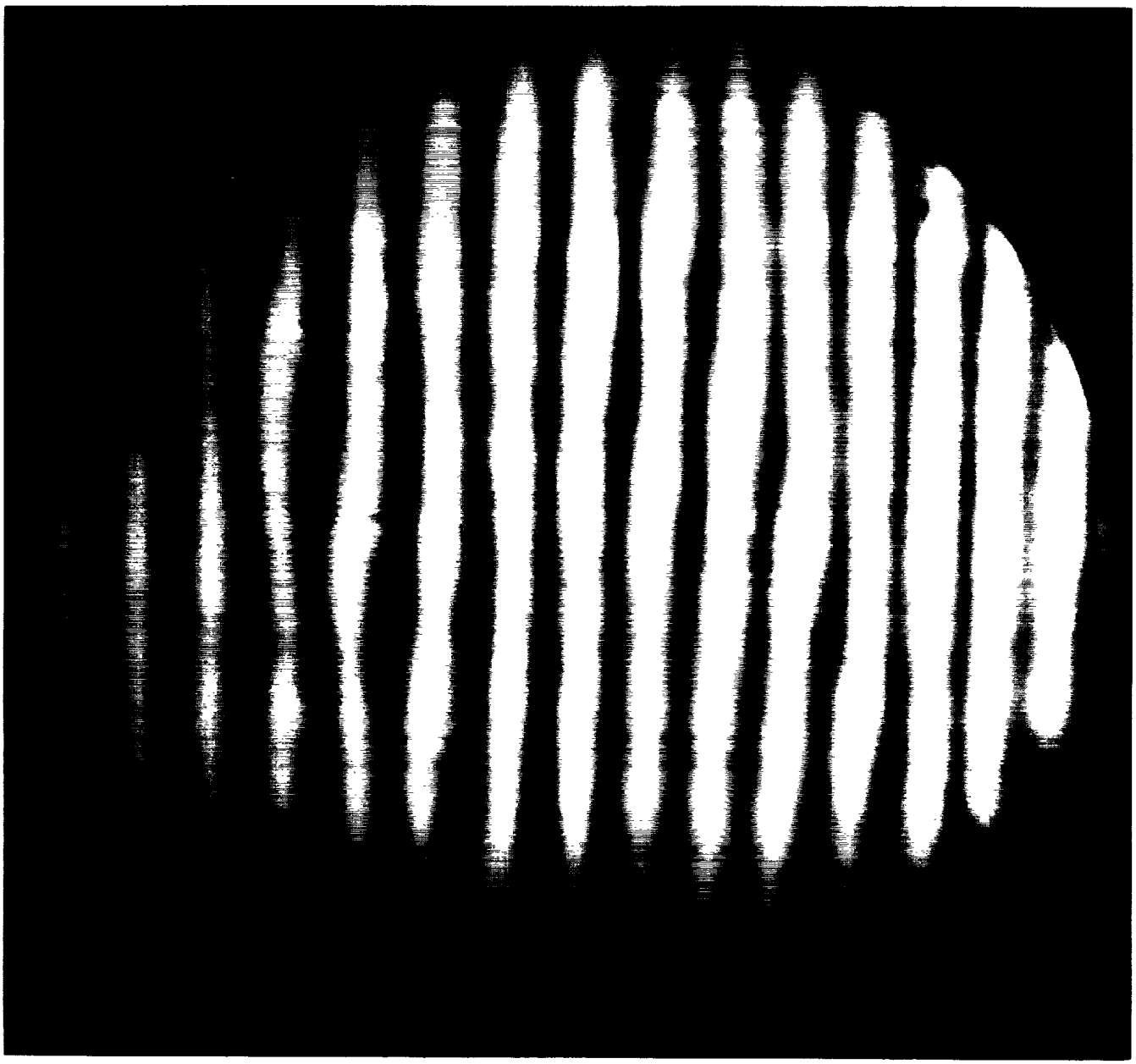

FIGURE 8. Polycarbonate, coating C-254, 0.040". Note large stria on center left.

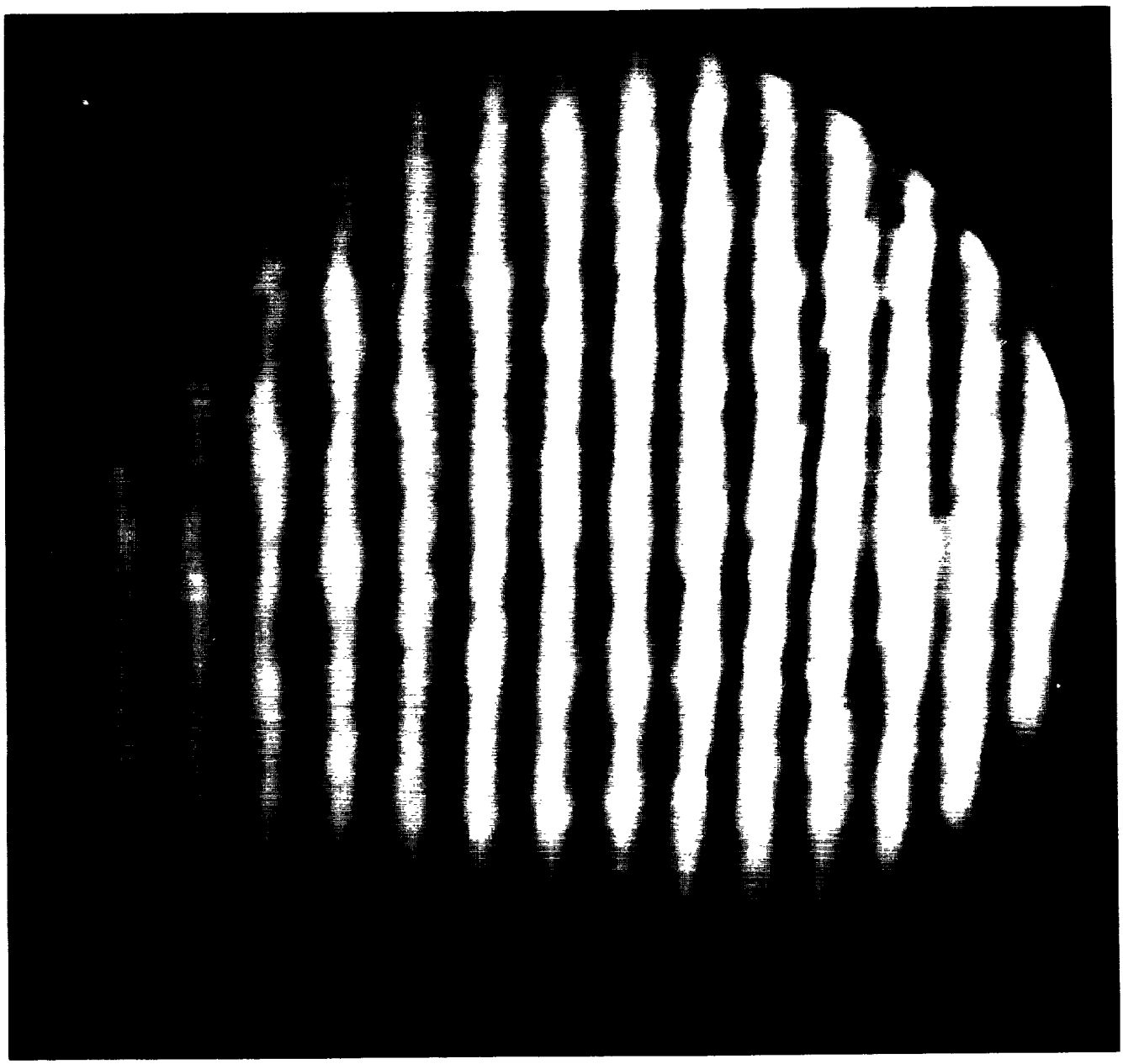

FIGURE 9. Polycarbonate, coating MXL, 0.030". Numerous small and large striae are present.

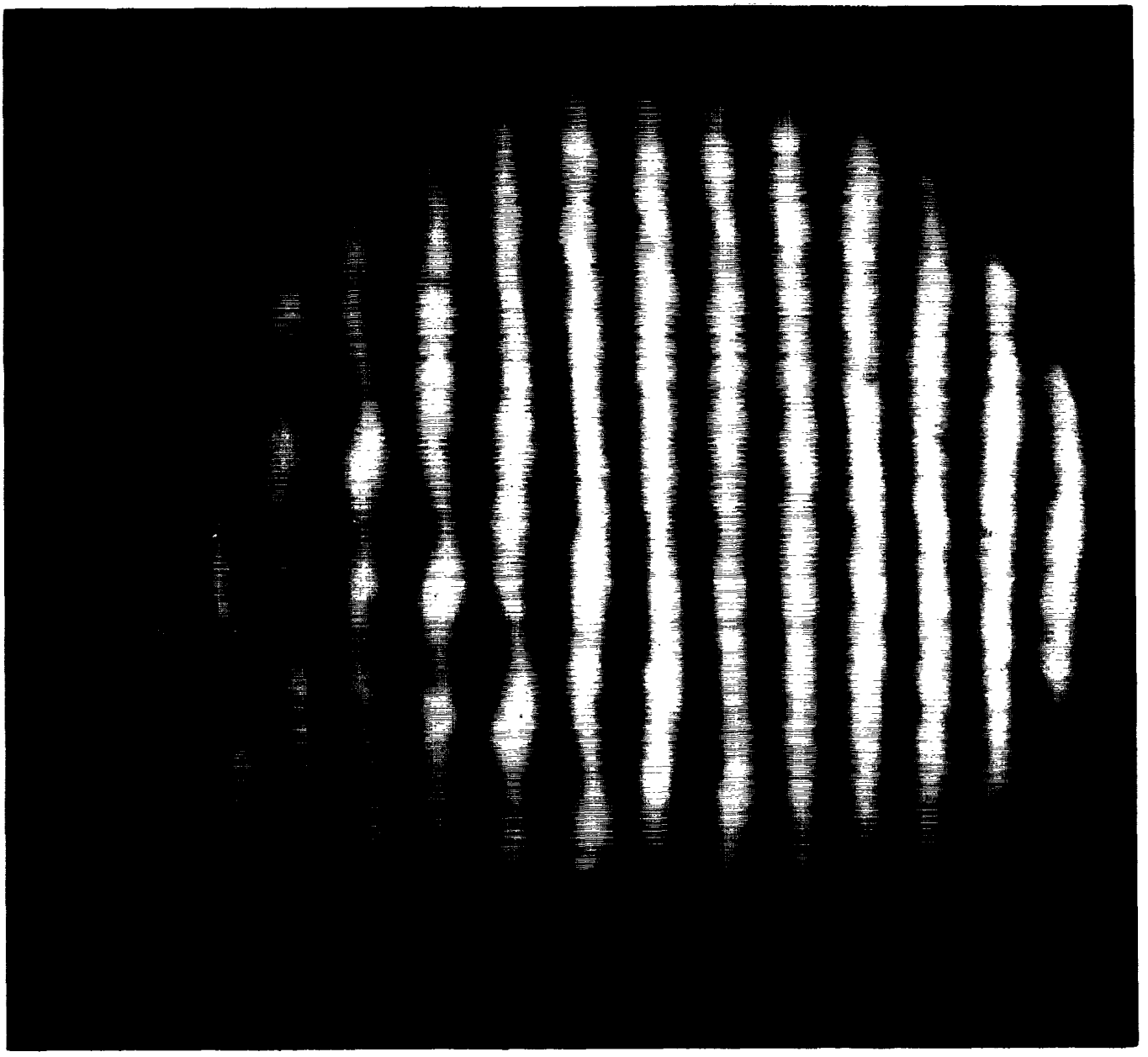

FIGURE 10. Polycarbonate, coating MXL, 0.040". Very large striae are evident.

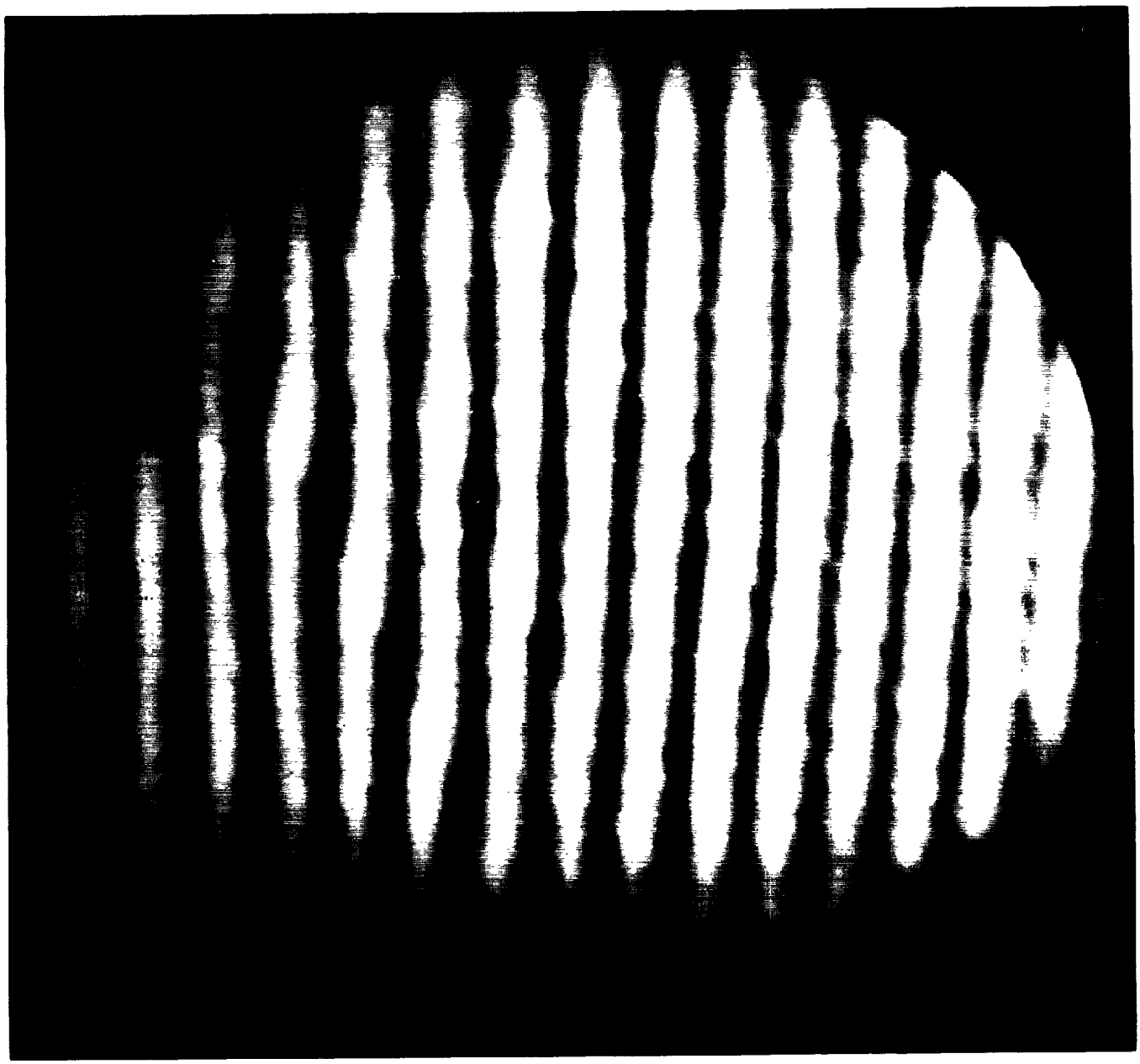

FIGURE 11. Polycarbonate, coating Abcite, 0.030". Small striae are pervasive.

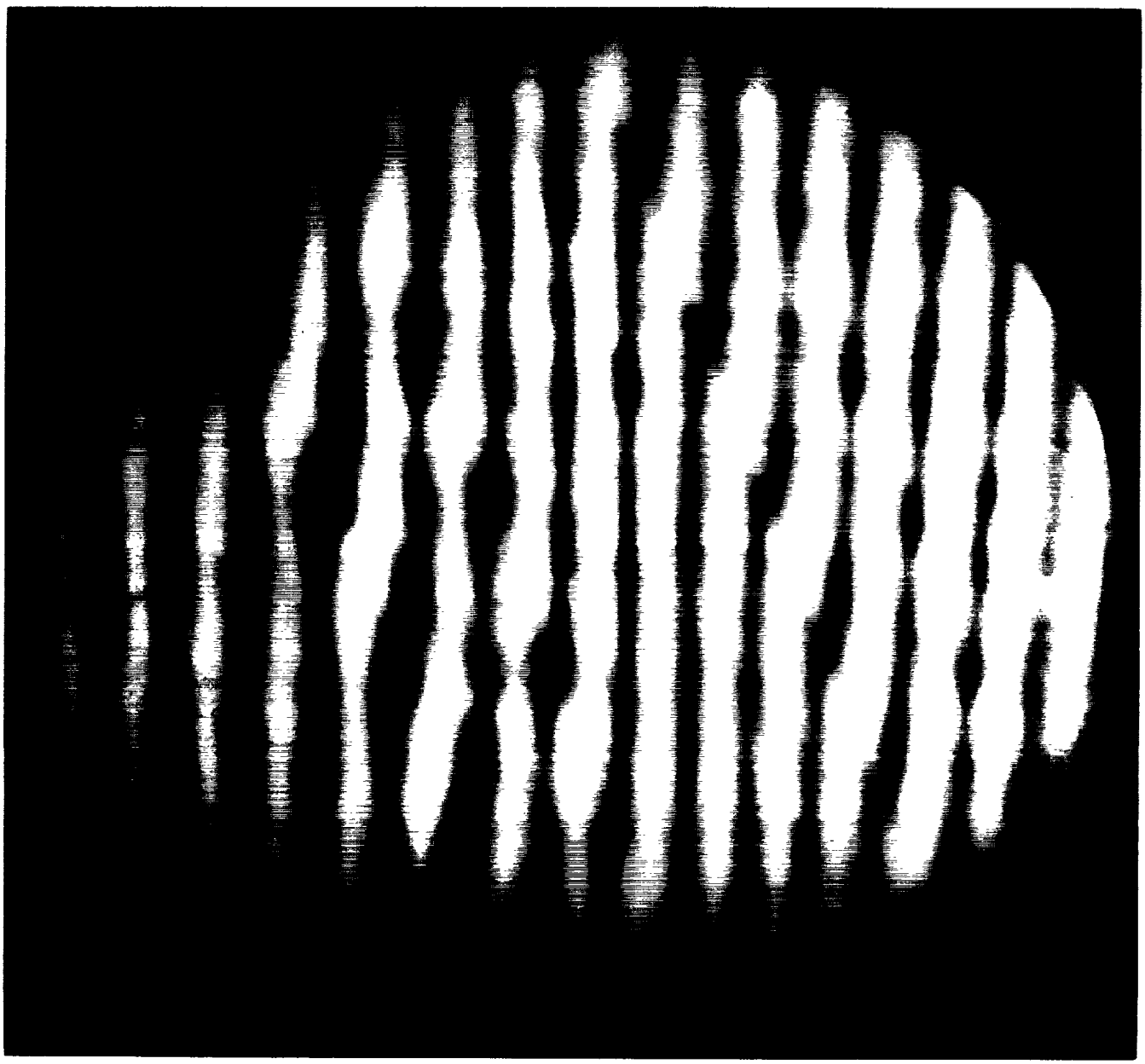

FIGURE 12. Polycarbonate, coating Abcite, 0.040". Large striae abound.

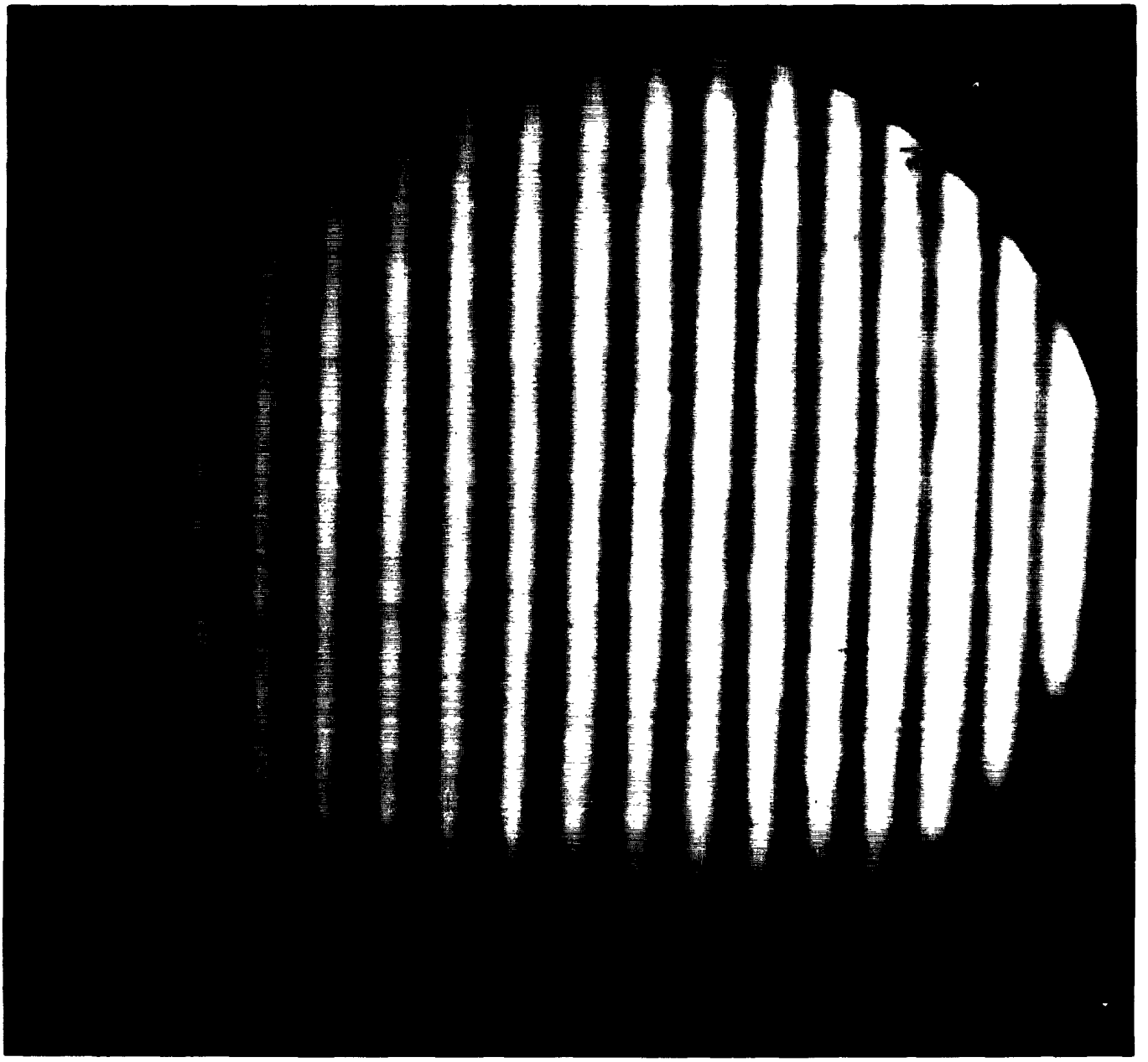

FIGURE 13. Polycarbonate aviator visor. Distortion is negligible. Blemish on left comes from a surface scratch.

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